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Reducing Climate Change in the UK: the discrepancies between strategy and implementation in the domestic building sector

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ABSTRACT AND KEYWORDS

Purpose of this paper

Using the new build residential sector in England as its basis, this study examines how climate change is being tackled, and the practicality of implementing various commitments of current and proposed UK legislation.

Design/methodology/approach

This paper outlines the current climate change facts, analyses the global, national, regional and local requirements for energy strategy and highlights the differences that have been found. The impact of different design strategies on achieving the various requirements is then modelled, using case study data. The design strategies tested in this case study includes the use of different levels of fabric insulation and airtightness, ventilation strategies, fuel types, and renewable energy systems.

Findings

The preliminary findings of this study show that the methods being used in the residential sector in England to tackle climate change are fraught with problems and that there are many conflicts in the interpretation of the requirements at different levels. They also show that the current additional cost of a sustainable building are prohibitively high. In order to successfully

implement environmentally sustainable solutions, there is a need for clearer regulations, guidelines and definitions, and for significant incentives.

Practical implications/value of the paper

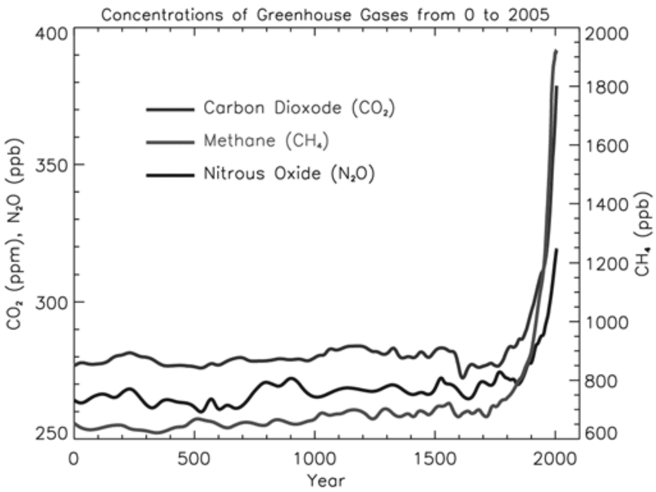
The study highlights the difficulties of implementing the UK energy and carbon dioxide commitments and makes a number of recommendations to make the implementation successful and to overcome the existing barriers.

Keywords

Climate change, sustainable construction, energy, carbon dioxide emission requirements, implementation

1. CLIMATE CHANGE

There is now very strong evidence (IPCC, 2007) that since the late 1800s the earth's average surface temperature has risen by 0.74˚C. During this



period, there has been an ever increasing consumption of fossil fuels as oil, gas and coal, significant deforestation, and the practice of farming methods that result in emissions of six principal greenhouse gases (GHG) (UN, 1998): Carbon Dioxide (CO_2), Methane (MH_4), Nitrous Oxides (N_2O), Hydrofluorocarbon (HFC), Perfluorocarbon (PFC) and Sulphur Hexafluoride (SF_6).

One reason for the current concern about climate change is the rise in atmospheric CO_2 concentrations indicated in parts per million as shown in Figure 1.1.

Figure 1.1 Concentrations of greenhouse gases from 0 to 2005 (IPCC, 2007)

Another concern relates to the speed of the recent warming. Average global temperatures have risen by 0.55˚C since 1940. During the ice age and warm interglacial periods the mean temperature changed between 4˚C and 7˚C, but this process took about 5,000 years (IPCC, 2007).
It fell to scientists to draw international attention to the threats posed by global warming. In 1988, the Intergovernmental Panel of Climate Change (IPCC) was created and the first assessment report issued. The Panel's findings spurred governments to create the United Nations Framework Convention on Climate Change (UNFCCC). In 2005, linked to the UNFCCC, the Kyoto Protocol entered into force that sets binding targets for 37 industrialized countries and the European Community for reducing GHG emissions.

In the year 2000 the world's GHG emissions were about $34GtCO_2e$ per year or $5.5tCO_2e$ per person. In 2006, the UK was responsible for a total of $652MtCO_2e$ of GHG emissions (DEFRA, 2008a), of which 85% have been CO_2 emissions (BERR, 2008). Data shows (DEFRA, 2008b) that the UK building sector accounts for 63% of this, and the residential sector is responsible for about 27% of the total CO_2 emissions in the year 2006. The heating sector (water and space) is responsible for 73% of the residential CO_2 emissions (DCLG, 2007).

2. INTERNATIONAL, NATIONAL, REGIONAL AND LOCAL ENERGY STRATEGY REQUIREMENTS

Different levels of hierarchy including international, national, regional and local intergovernmental/governmental institutions define energy strategies and set out targets for tackling climate change.

The UNFCCC is the overall framework for intergovernmental efforts to tackle the challenge posed by climate change. The core commitment under its Kyoto Protocol requires each committed industrialized country to ensure that its total emissions from the main six greenhouse gas resources do not exceed agreed levels.

Reducing energy consumption is among the main goals of the European Union (EU). With 40% of the energy consumed by 160 millions buildings (CIBSE, 2003), the EU has introduced the Energy Performance of Buildings Directive (EPBD, 2002). The EPBD aims to ensure that new buildings consume less energy and that the EU commitments and targets are kept.

In response to this directive, the UK Government set targets to cut the national CO_2 emissions by 80% by 2050, to save 20% of the European Energy Consumption by 2020 and to increase the renewable energy supplies by 20% by 2020.

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To achieve these targets, the Government amended the Building Regulations (BR) Approved Document Part L in 2006 (ODPM, 2006) and is consulting on the changes that will come into force in October this year. Compliance with BR is mandatory. In addition, the UK Government introduced the Code for Sustainable Homes (CSH) (DCLG, 2008). The CSH is a discretionary environmental assessment method for rating and certifying the performance of new dwellings from level 1 (enhanced sustainability) to level 6 (zero carbon).

On a regional level the Greater London Authority (GLA, 2004a) published its Energy Strategy. The strategy aims to improve London's environment, reduce the capital's contribution to climate change, tackle fuel poverty and promote economic development by using less energy, using renewable energy and supplying energy efficiently.

On a local level, Richmond upon Thames is an exemplary Borough putting sustainability as a priority in its Core Local Development Strategy (LBRUT, 2009a). The Borough requires every new development to comply with its supplementary planning document, the Sustainable Construction Checklist (LBRUT, 2009b). The Checklist requires an excellent environmental rating for all new residences which is equivalent to a CSH level 3 and the predicted site CO_2 emissions have to be reduced by at least 20% through the use of renewable energy. Local policy therefore overrides regional and national policy.

3 .CASE STUDY

3.1 The exemplary dwelling, calculation model and the assumptions

The dwelling chosen for this research is a real development located in a suburban area in the South West of London. The dwelling is a two storey, detached property with a total floor area of approximately $160m^2$.

All calculations have been performed with the National Home Energy Rating (NHER) Plan Assessor Version 4.2.28. The NHER Plan Assessor software is government approved and authorised for Standard Assessment Procedure (SAP 2005), Environmental Impact (EI), Target Emission Rate (TER), Dwelling Emission Rate (DER) calculations and for issuing Energy Performance Certificates (EPC).

It is assumed that the dwelling is naturally cooled, no secondary heating system is specified, no chimneys and open flues are present and in total three extract fans are installed in kitchen and bathrooms.

The primary heating systems tested include gas boiler, warm air, warm air with heat recovery, biomass boiler, ground source and air source heat pumps and a communal combined heat and power (CHP) system. They are time and temperature zone controlled. Appropriate systems for an urban context, such as photovoltaic elements, solar hot water elements, biomass boiler, ground source and air source heat pumps have been tested to comply with the local planning requirement to offset at least 20% of the predicted CO_2 emissions by renewable technologies.

Two different types of construction standards have been analysed:
1. Standard construction: the dwelling complies with BR Part L1A
2. Improved construction: the dwelling exceeds BR Part L1A requirements

Table 3.1 Assumptions made for the construction elements of type one and two

Building Element	Type 1, standard construction	Type 2, improved construction
Floor, external wall, roof	0.25W/m^{2}K	0.12W/m^{2}K
Windows	2.0W/m^{2}K	0.8W/m^{2}K
Doors	2.0W/m^{2}K	1.0W/m^{2}K
Air tightness level	9m^3/m^{2}hr@50Pa	5m^3/m^{2}hr@50Pa

3.2 Results of the analysis

3.2.1 The methodology to demonstrate the energy performance of a dwelling

In England, different calculations are required to demonstrate compliance solely with the energy performance of new build dwellings. To prove compliance with BR Part L1A and to produce Energy Performance Certificate (EPC) for SAP-ratings, SAP calculations are required.

For both verifications SAP determines the CO_2 emissions arising from the predicted energy demand of the dwelling, however, the CO_2 emissions through cooking and electrical appliances are disregarded. In addition, the assumptions made for secondary heating and for the use of energy efficient lighting are different.

For Part L1A the calculations determine the CO_2 emissions of the actual dwelling (DER) and these are compared with those of a notional dwelling, defined as the Target Emission Rate (TER). To comply with BR, the DER has to be equal to, or lower than the TER.

For Part L1A it is assumed that a secondary heating appliance always meets part of the space heating demand. The fraction provided by the secondary heating system is defined in SAP (BRE, 2008) and the efficiency is assumed as defined in Part L1A. For lighting, a fixed assumption of 30% low energy lighting is made.

To determine the SAP-rating for EPCs, the Environmental Impact Rating (EI) and the Energy Efficiency Rating (EE) need to be calculated. The calculation procedures for both ratings are also based on the DER.

However, contrary to Part L1A, for EPCs the efficiency of the secondary heating system is as actually designed.
The CO_2 emissions from lighting are based on average energy consumption for lighting in UK houses and include a correction factor for fixed lighting systems.

Therefore, the CO_2 emission results of Part L1A and EPC calculation procedures vary as indicated in Figure 3.1 but are expressed using the same terminology “DER”. In addition, Figure 3.1 shows realistic CO_2 emissions (NHER), reflecting the emissions arising through cooking and electrical appliances.

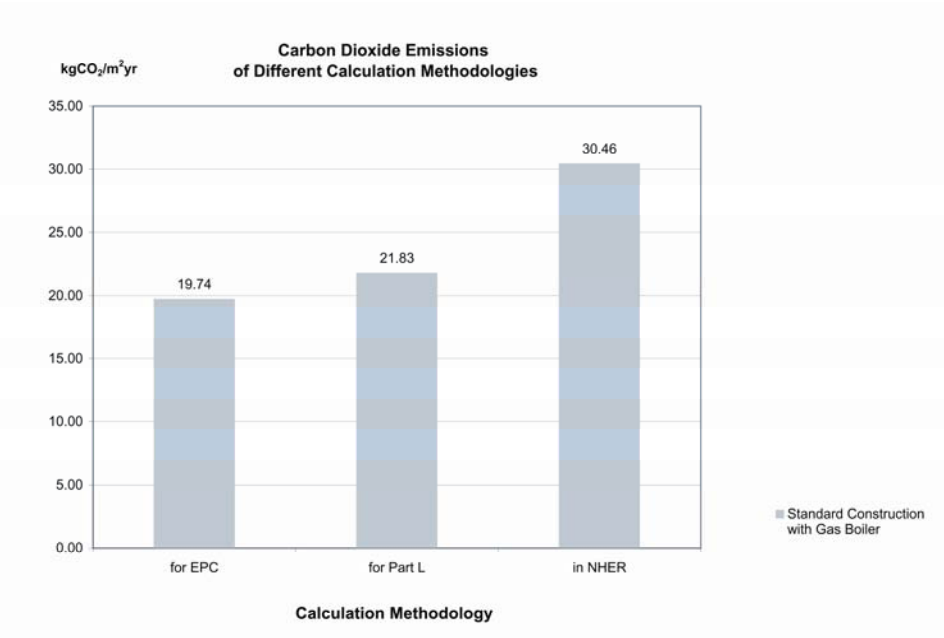

Figure 3.1 Predicted CO_2 emissions for house type 1 as defined for EPCs, Part L1A compliance and by NHER

3.2.2 The energy and carbon dioxide targets

Figures 3.2 and 3.3 demonstrate that the best heating option in terms of CO_2 emissions is not the best option in terms of energy demand.

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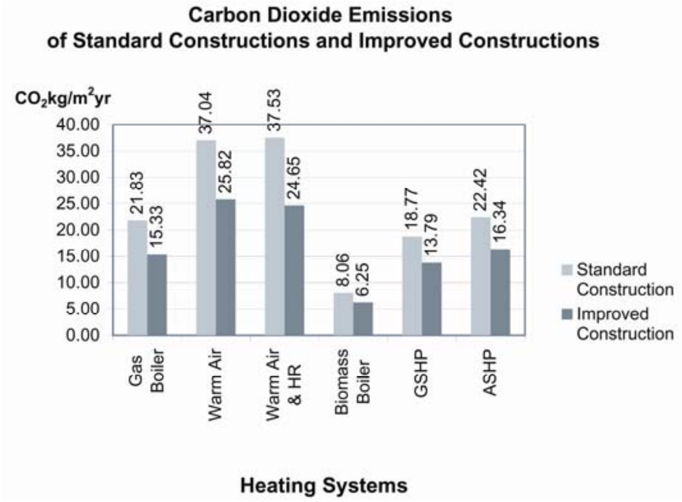

Figure 3.2 CO_2 emissions (DER) for different heating strategies for house types 1 and 2

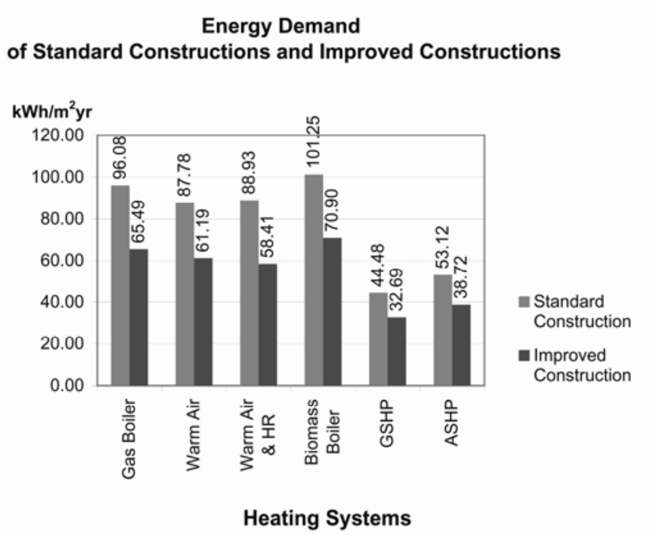

Figure 3.3 Energy demand for different heating strategies for house types 1 and 2

The biomass boiler has for both construction types the lowest DER but the highest energy demand, whereas the options providing ground source heat pumps as heating systems show the best performances in terms of energy demand but have only average DERs. These discrepancies between energy demand and CO_2 emissions result from the divergent efficiencies of the heating systems, and the divergent CO_2 emissions that are released by producing the different fuel types (gas, electricity).

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Therefore the definition of the DER as a decisive factor to conserve fuel and power is in conflict with the target to implement energy efficient heating solutions. Furthermore it is not reflected, that in the near future the proportion of electricity generated by renewable energy systems will increase and therefore heating systems running on electricity will have lower CO_2 emissions.

3.2.3 Cogeneration of heat and electricity

One target of the Mayor of London (GLA, 2004b) is to improve the use of efficient technologies, such as CHP systems. According to Grindfeld (BSD, 2009) CHP systems achieve 30% higher efficiencies than systems that produce heat and electricity separately. Figure 3.4 shows that the CO_2 emissions of a communal gas CHP system are the lowest of the systems tested.

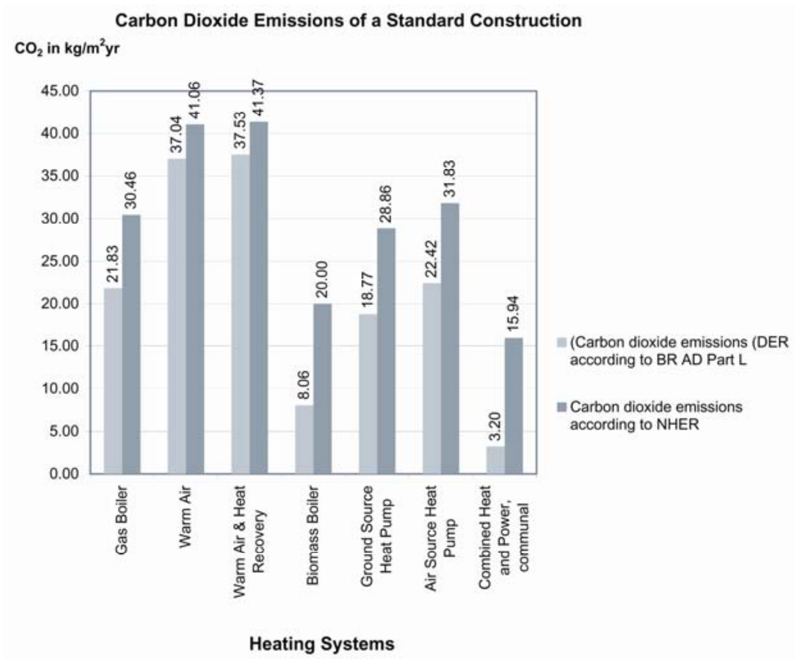

Figure 3.4 CO_2 emissions of different heating strategies including gas CHP of house type 1

Gas CHP systems are defined as Low or Zero Carbon Technologies in the CSH (DCLG, 2009) but are not recognised as renewable energy systems as defined in the London Toolkit (STI, 2004). Therefore, the CSH awards credits for the provision of gas CHP systems, however, they do not count towards the 20% renewable energy requirement of the Boroughs.

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Therefore, although gas CHP systems are significant energy saving measures, in practice they are not often incorporated, as the capital cost for CHP systems are higher than those of gas boilers and additional investment has to be made to comply with the renewable energy requirements.

3.2.4 Renewable Energy versus Low or Zero Carbon Technologies

The CSH awards credits for the incorporation of Low or Zero Carbon Technologies (LZC). To demonstrate compliance, the CO_2 emissions of the actual dwelling are compared with those of a “Standard Case”, as defined in the CSH Technical Guide (DCLG, 2009).

On a local policy level a similar requirement becomes a mandatory criterion: to offset the predicted CO_2 emissions by at least 20% on-site renewable energy technologies. The systems that are accepted as renewable energy technologies vary on different policy levels, a generic definition is hard to find and they are divergent to the definition of LZC technologies. In order to demonstrate compliance, complex and confusing calculations are required. The CO_2 emissions of the actual dwelling are compared with those of a “Base Case”, which is defined differently than the CSH “Standard Case”.

In addition, Figure 3.5 shows that to meet the 20% renewable requirement the amount of energy generated from additional renewable technologies (for example photovoltaic or solar hot water panels) increases with improved construction standards where the primary heating system is a renewable energy technology, for example a GSHP, an ASHP, a biomass boiler. This clearly does not promote good basic design.

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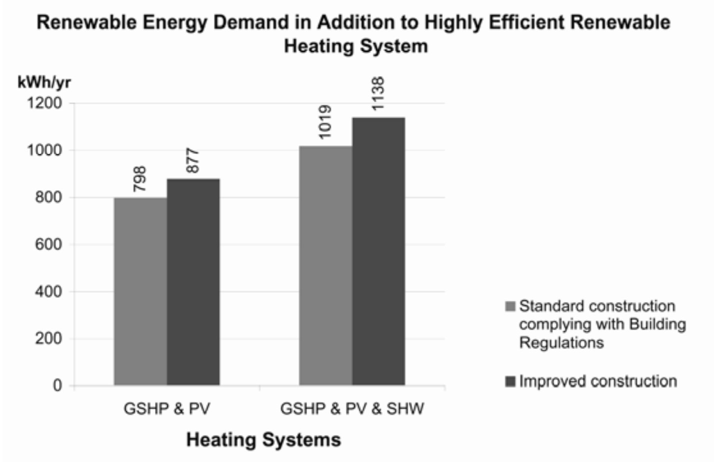

Figure 3.5 Amount of electricity generated by additional renewable energy technologies (photovoltaic and solar hot water panels) incorporated to house Types 1 and 2 in order to meet the 20% renewables requirement

3.2.5 Financial aspect

The cost for the additional sustainability requirements arise through improved construction standards and building services, the cost for the renewable energy technologies and the procedures for the CSH assessment and certification. From experience it can be seen that the additional cost of achieving for example CSH level 4 and to incorporate 20% renewable energy technologies to a typical dwelling range between US $15,000-25,000.

Of the tested options, the biomass boiler has the shortest payback period time of less than 10 years and the heat pumps have the longest payback periods of approximately 25 years. The installation of a GSHP is complex and therefore expensive, and both heating systems running on electricity have a very low contribution towards the 20% renewable requirement as defined by the Borough. Therefore additional renewable energy technologies have to be provided which generate additional expenses.

To overcome the financial barriers several schemes have been put into place by the UK Government. Until 2011 grants are available for the installation of Low or Zero Carbon Technologies for new build residential developments. Stamp Duty Exemptions up to 4% are available for the first acquisition of zero-carbon homes. From April this year, a Feed-In-Tariff is paid for every kWh of electricity generated by renewable energy systems and a Renewable-Heat-Incentive is announced to be launched by 2011.

However, the financial incentives are complex and refer to various terminologies such as renewable energy systems, energy-generating technologies, energy-saving technologies, micro-generation, macro-generation and low or zero carbon technologies, which is confusing, and they cover only a fraction of the additional cost of a sustainable new building.

4. CONCLUSIONS

To implement the targets to tackle climate change, three strategies are pursued in the building sector of the UK: to be lean, to be clean and to be green. The implementation of these three strategies is regulated by the mandatory BR and the optional CSH on a national policy level and the mandatory supplementary sustainability planning documents on a regional and a local level.

The study undertaken shows firstly, that these regulations are not in line with each other and vary from region to region and from Borough to Borough. Their implementation therefore becomes confusing and unnecessarily complex.

Secondly, the applied methodology of implementing the strategies “be lean” and “be clean” and “be green” are complex and conflicting.

Thirdly, the case study shows that the calculation procedure to determine the energy demand of dwellings is based on the CO_2 emissions which disregard the energy demand of cooking and electrical appliances. In addition, the calculations do not reflect that the heating systems that run on electricity and therefore are more energy efficient than systems running on gas will be less carbon dioxide intensive in the future, as a higher proportion of electricity will be generated by non-fossil fuels. Therefore these systems are often not incorporated to new designs which will be the building stock of the future.

In conclusion, the implementation of the strategies to tackle climate change becomes unnecessarily confusing, complex and therefore time-consuming and expensive. To overcome these barriers and to successfully tackle climate change, a number of recommendations can be made:

1. Targets and strategies addressing the reduction of the remaining 5 principle greenhouse gases but CO_2 are required.
2. Regulations are required that are valid on every policy level.
3. The calculation procedures for compliance with these regulations need to be clearly defined, and consistent, include all energy consuming processes of a dwelling and allow for situations where there is no primary heating system.
4. To overcome the conflicts and difficulties between the targets to be lean, to be green and to be clean, the required evidences need to be based on the predicted primary energy demand of the dwelling in kWh/m^2yr, rather than on the CO_2 emissions in kg/m^2yr.

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5. One terminology, a clear definition of "renewable energy technologies" and a simple calculation procedure to demonstrate compliance with the renewable energy requirements need to be agreed.
6. Transparent, easily accessible and lucrative financial incentives need to be offered to build environmentally sustainable buildings.

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